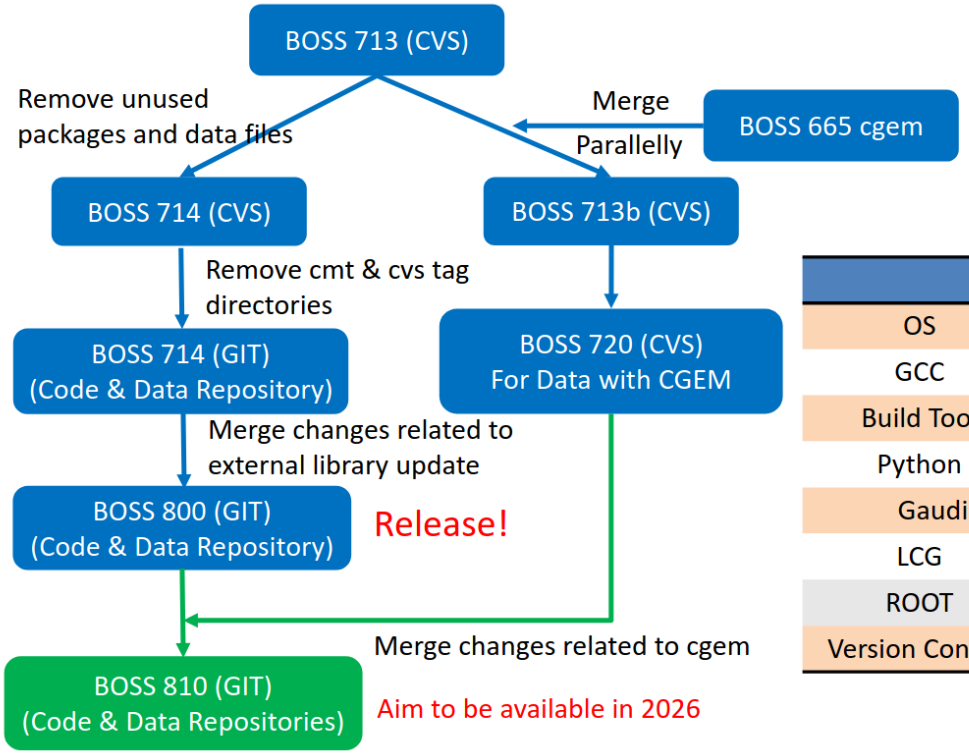
CGEM software

Status, developments, plans, needs

BESIII Italia – LNF - 15/12/2025

News from the last CM

Upgrade to Alma Linux 9 and External Libraries



Done
On going
To do

LI Mingrun
MA Qiumei
DENG Ziyan
ZOU Jiaheng
JI Xiaobin
WANG Liangliang

	BOSS 7.1.3	Upgraded Version
OS	CentOS 7	AlmaLinux 9.4
GCC	4.9.3	GCC 13
Build Tool	cmt	CMake 3.26.2
Python	2.7.10	3.11.9
Gaudi	v27r1	V38r2
LCG	LCG_84	LCG_106
ROOT	6.20.02	6.32.02
Version Control	CVS	git

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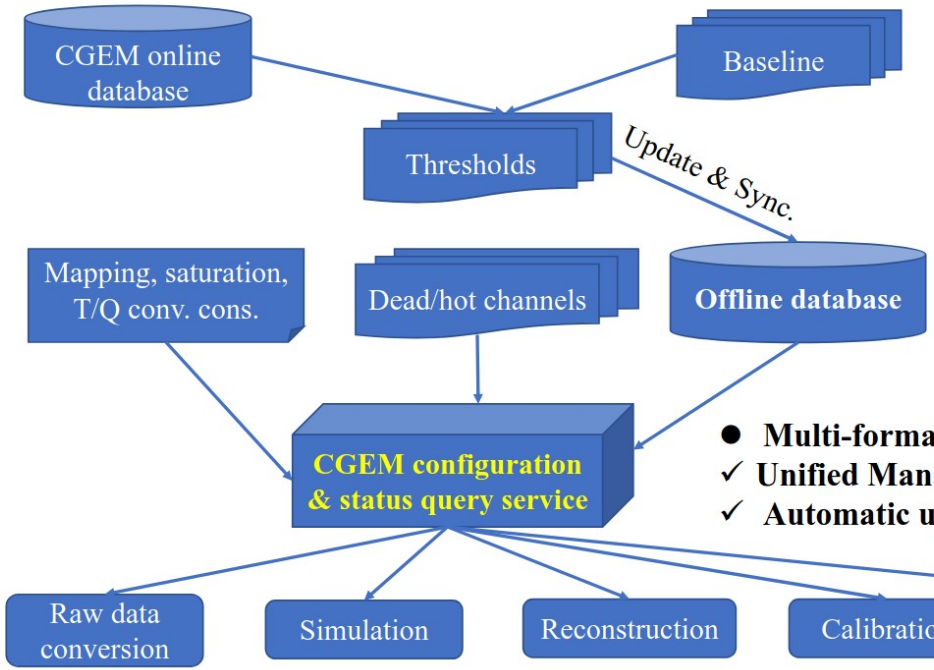
News from the last CM

CGEM configuration and status query service



Hao Yuan, Qiumei Ma et al. (IHEP)

CGEM configuration & status

- Mapping
- Saturation
- Charge/time conversion constants
- Thresholds
- Dead/hot channels (not Fully Operational yet)
- HV ...

- **Multi-format sources and run/channel dependence**

✓ **Unified Management and Access in offline**

✓ **Automatic update between runs**

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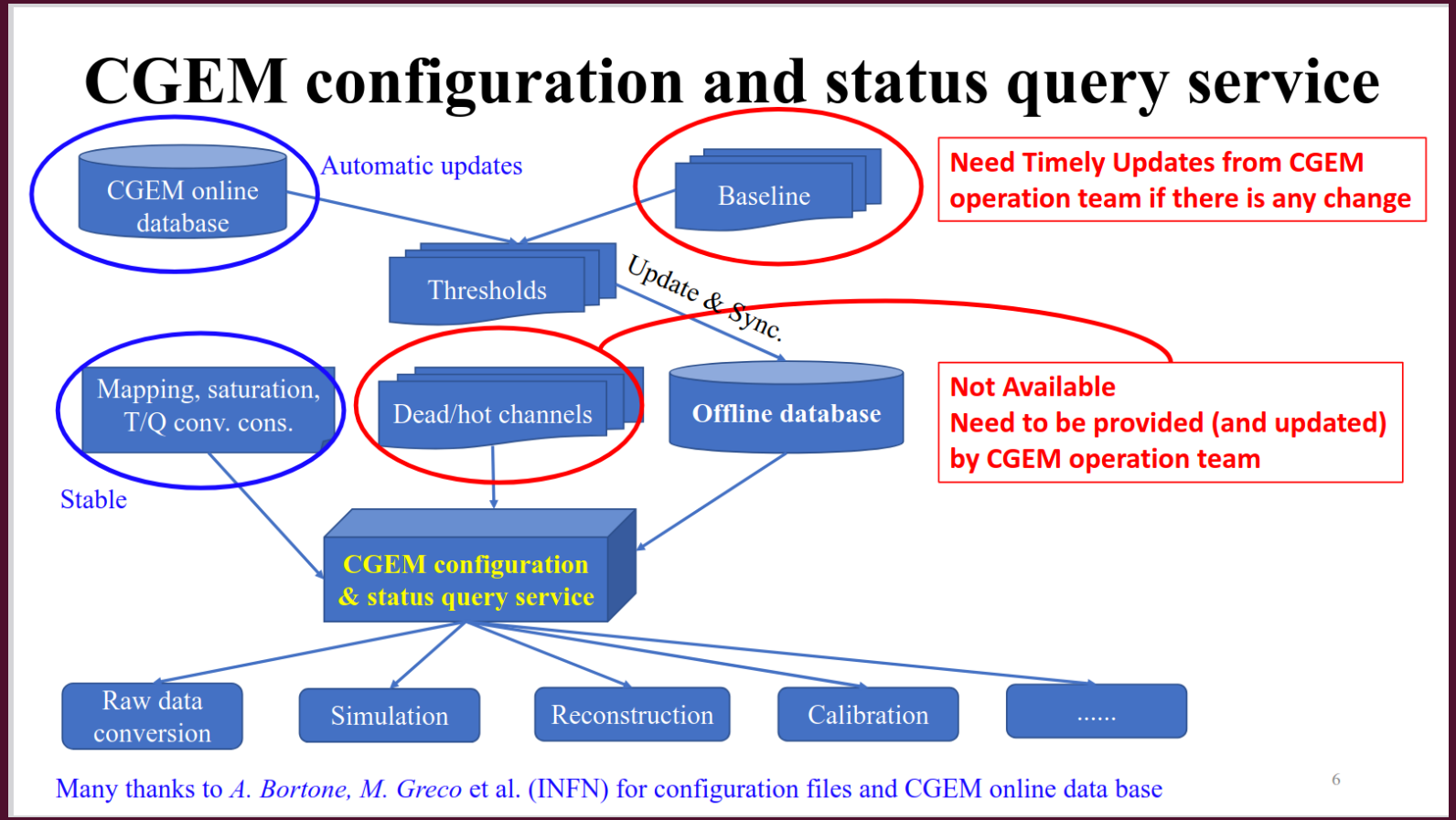
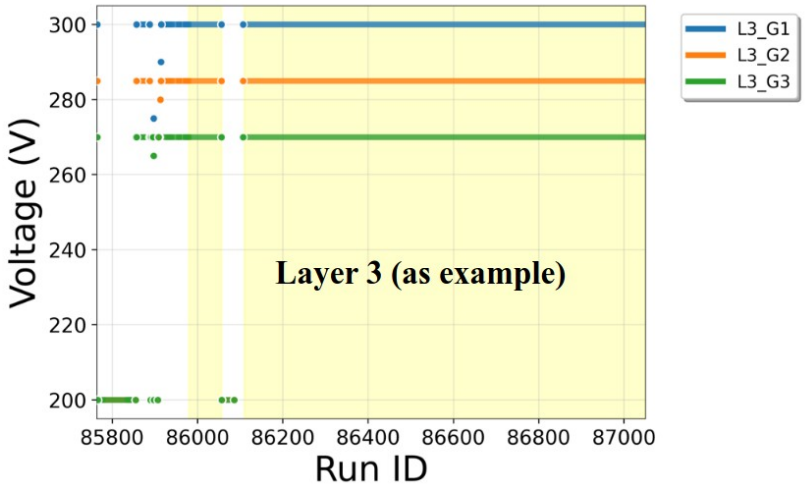
News from the last CM



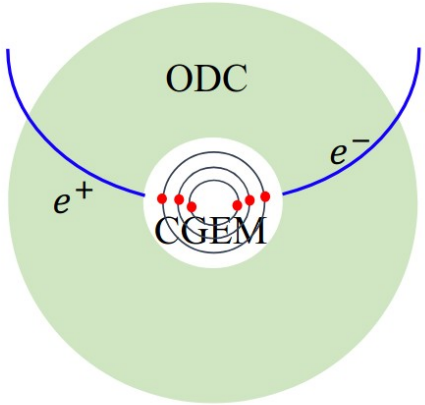
News from the last CM

Runs with stable CGEM HV and Bhabha selection



Bhabha selection with ODC tracks

- Two good charged tracks, Q=0
- Back to back
- EMC energy and momentum requirements



- HV stable for all layers in run 85980~86056 and run 86110~87050 (22 Jun ~30 Jul , yellow region)
- These runs taken for the CGEM digitization tuning study

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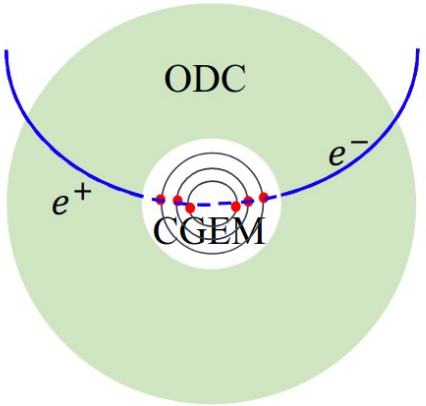
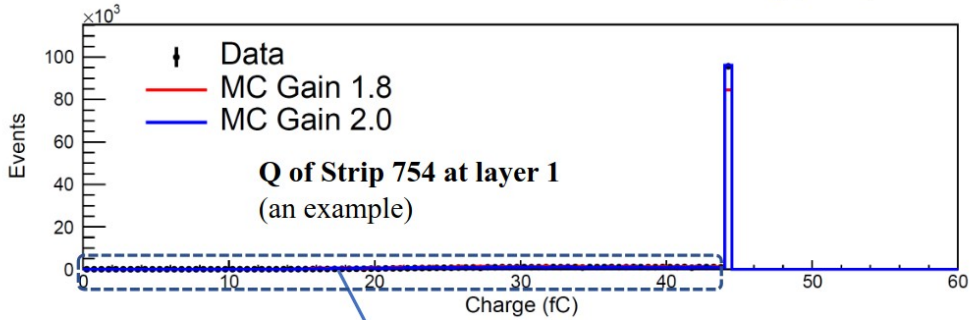
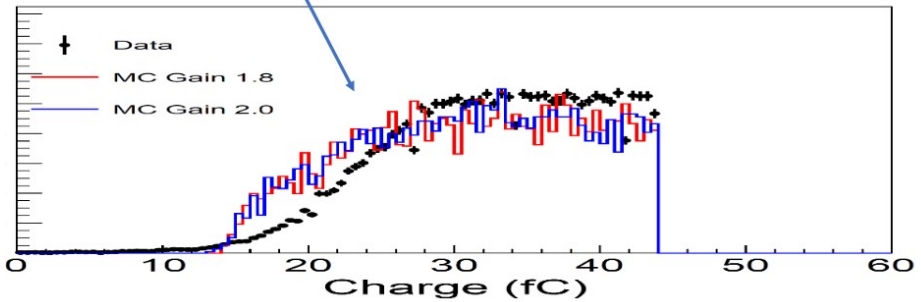
News from the last CM

CGEM digi selection and charge comparison

Xinnan Wang (IHEP) et al.







- ODC tracks extrapolated into CGEM to find the closest clusters within a window
- Digis in the found closest cluster are selected for MC/data comparison

=> Background much reduced

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News from the last CM

CGEM full digitization tuning steps

Parameters	Distribution for comparison
1. Gain	Total charge of 2-D cluster
2. Charge sharing	Peak of charge sharing ratio of V cluster over X cluster
3. Charge fluctuation	Width of charge ratio of V cluster over X cluster
4. Electron diffusion (spatial)	Cluster Size
5. Time	Time distribution

- The order of tuning is carefully considered
- Work in progress

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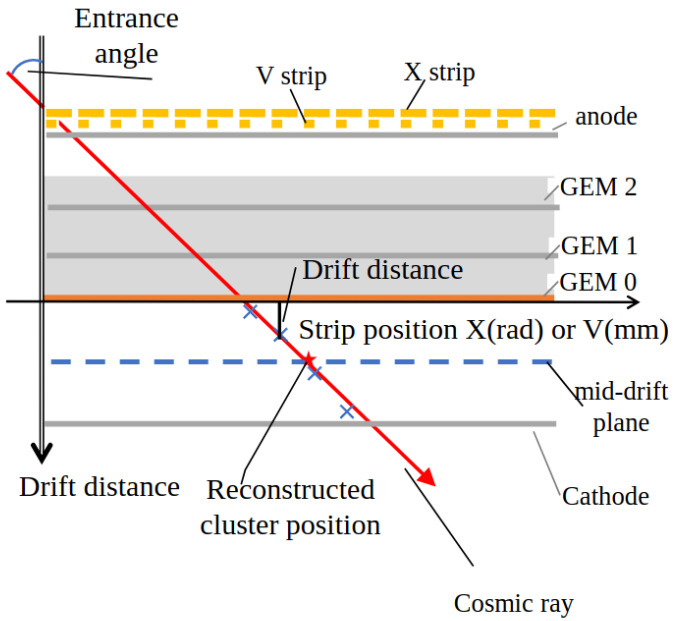
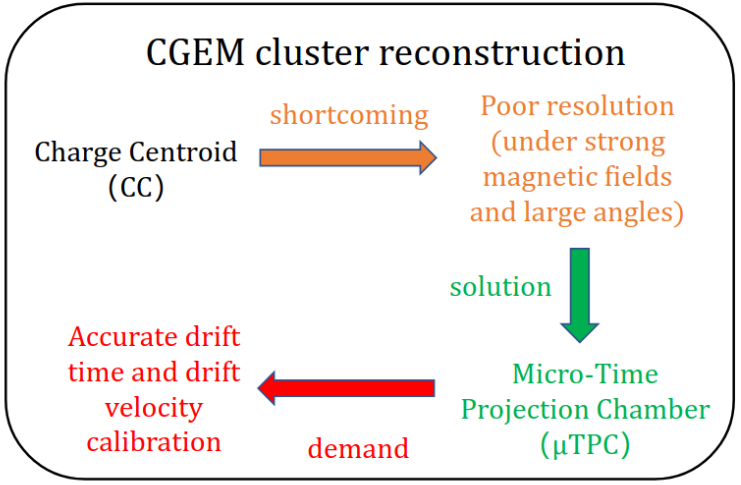
News from the last CM

Introduction——μTPC





The basis for calibration is a deep understanding of the detector response and the data

- Use MC to comprehend the detector response
- Quality inspection and research understanding of data

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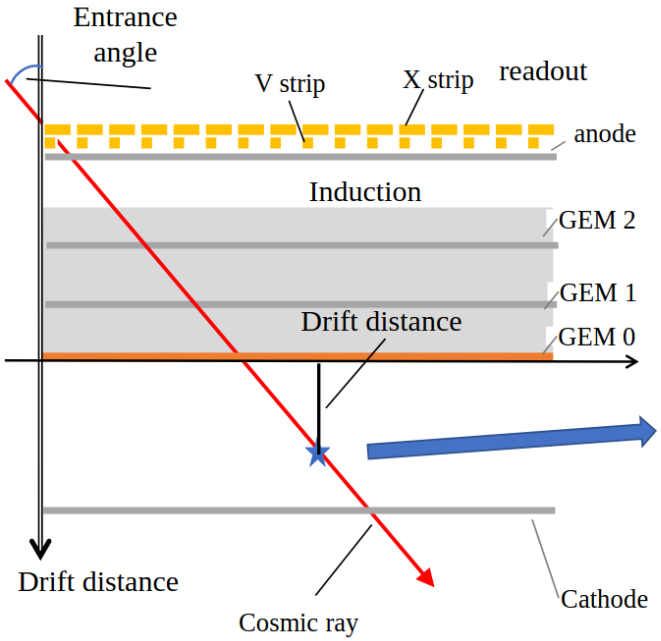
News from the last CM

MC Simulation



For one ionized cluster

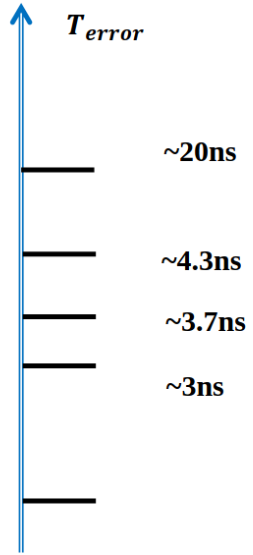
$T_{readout}$: 2ns(jitter) + 15ns(Time Walk)

$Q_{readout}$: ~3fC

sampling: ~2ns

sampling: ~2ns

drift : ~3ns



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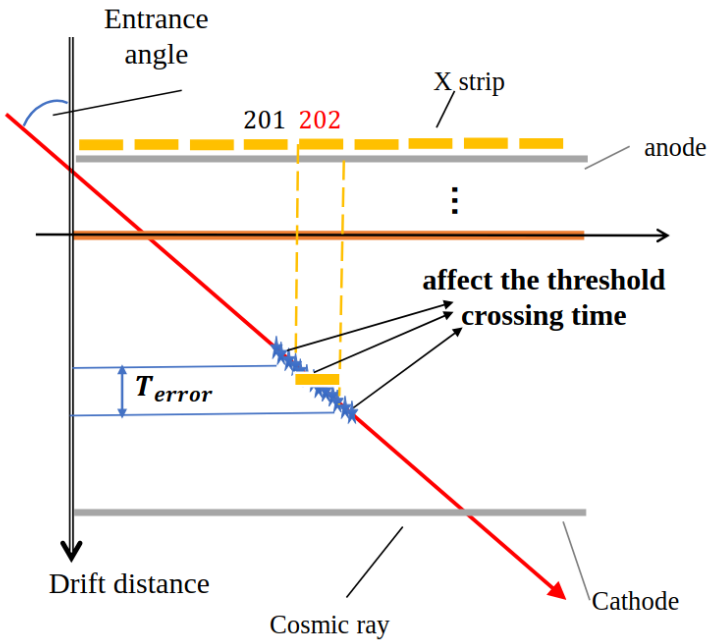
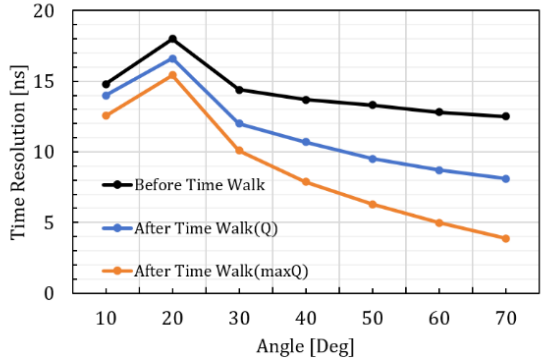
News from the last CM

Time Resolution —— Strip-width



Use Specialized MC:

- Fixed cosmic ray track at different Entrance angle
- Only studying layer 2,sheet 0, strip X 202



The main impact on time resolution:
@small angels: Strip-width ~15ns
@large angels: Time Walk ~10ns

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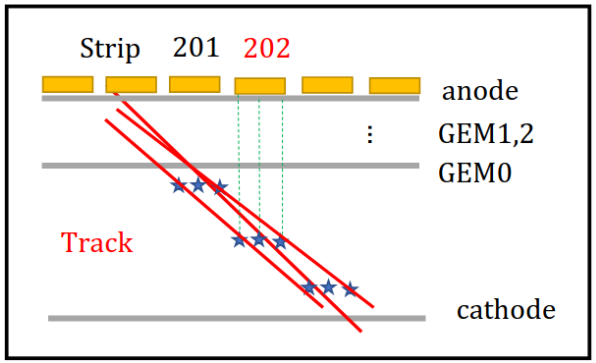
News from the last CM

Time Resolution —— Strip-width

In cluster reconstruction, use more possible positions for each strip (1 -> 3)



- Use more points to reduce time fluctuations caused by Strip-width
- Previously, the middle position of each strip was used as the input point for line fitting
- Now, three points with the same drift distance (located at the beginning, middle, and end of the strip) are taken for line fitting
- Select the best fitting results to calculate the center position of the cluster

We are conducting fitting studies using Phi as a free parameter, including both internal cluster fitting and joint fitting across the six layers

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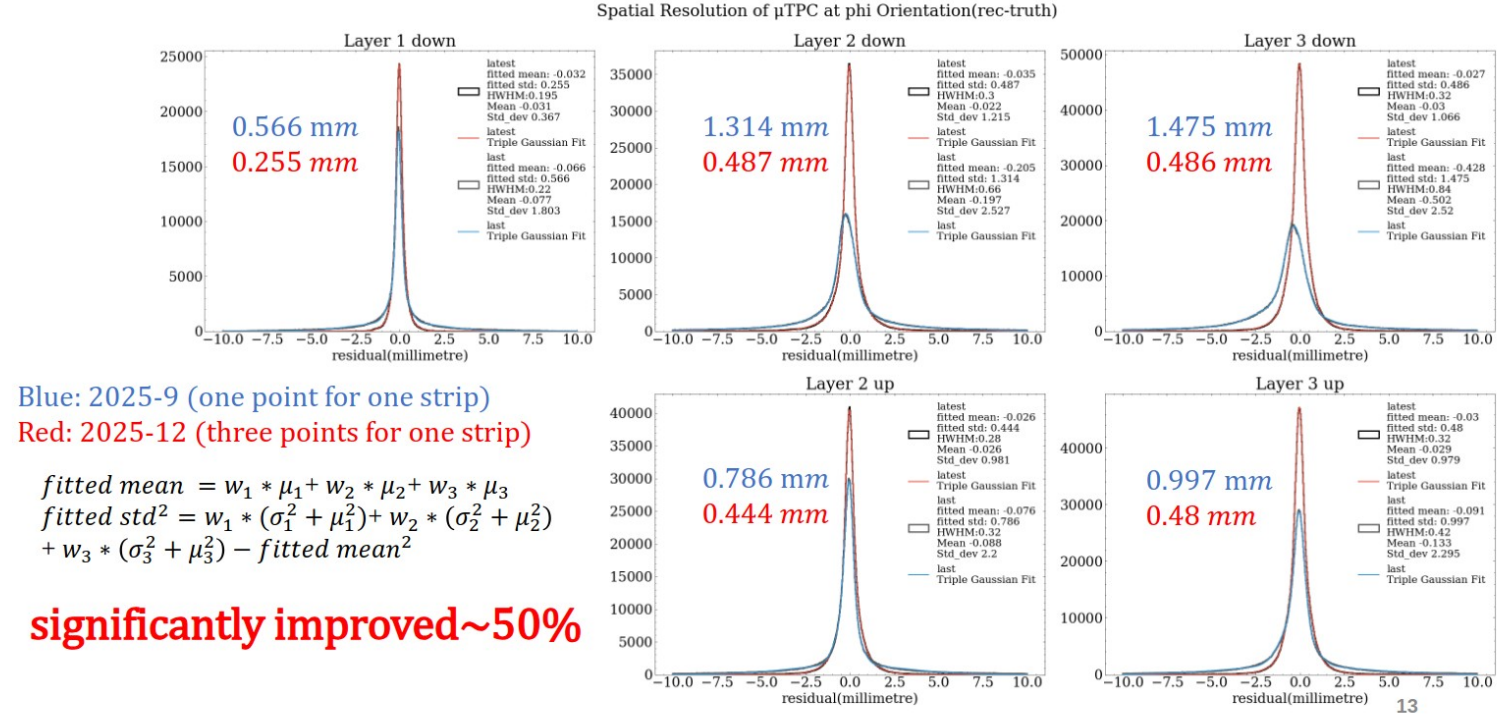
News from the last CM

Cluster Spatial Resolution at phi



Blue: 2025-9 (one point for one strip)
Red: 2025-12 (three points for one strip)

$$fitted\ mean = w_1 * \mu_1 + w_2 * \mu_2 + w_3 * \mu_3$$
$$fitted\ std^2 = w_1 * (\sigma_1^2 + \mu_1^2) + w_2 * (\sigma_2^2 + \mu_2^2) + w_3 * (\sigma_3^2 + \mu_3^2) - fitted\ mean^2$$

significantly improved~50%

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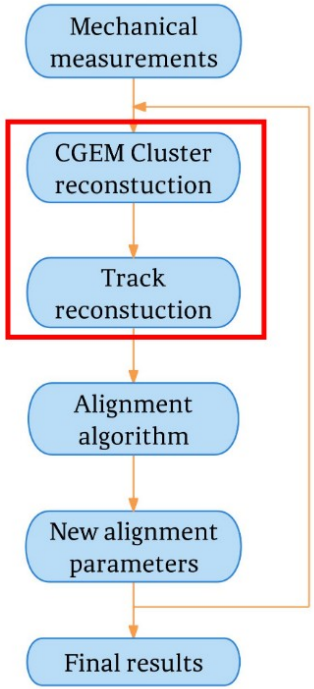
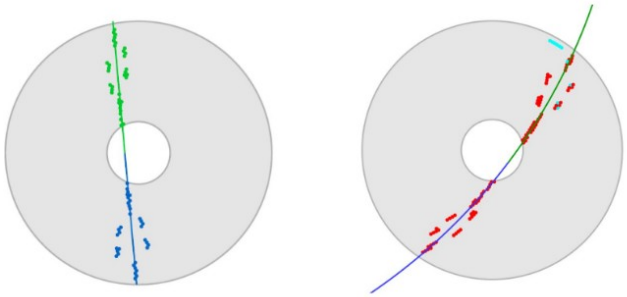
News from the last CM

Reconstruction for cosmic ray data



- CGEM cluster reconstruction method: Charge Centroid (CC)
- Track reconstruction
  - Without magnetic field: Hough Transform method
    Refer to Prof. Wu's report in Xinxiang on March 17, 2025
  - With magnetic field: Legendre Transform method
    Refer to Yaxuan's report in Beijing on July 7, 2025



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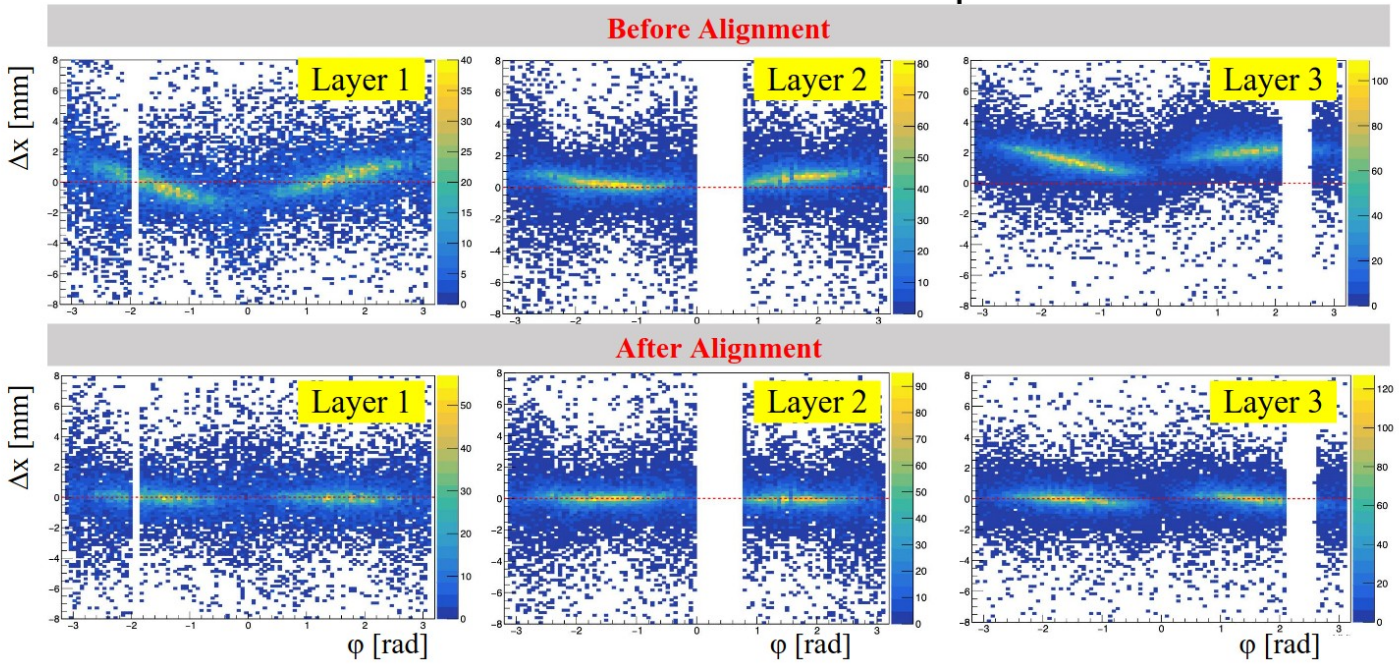
News from the last CM

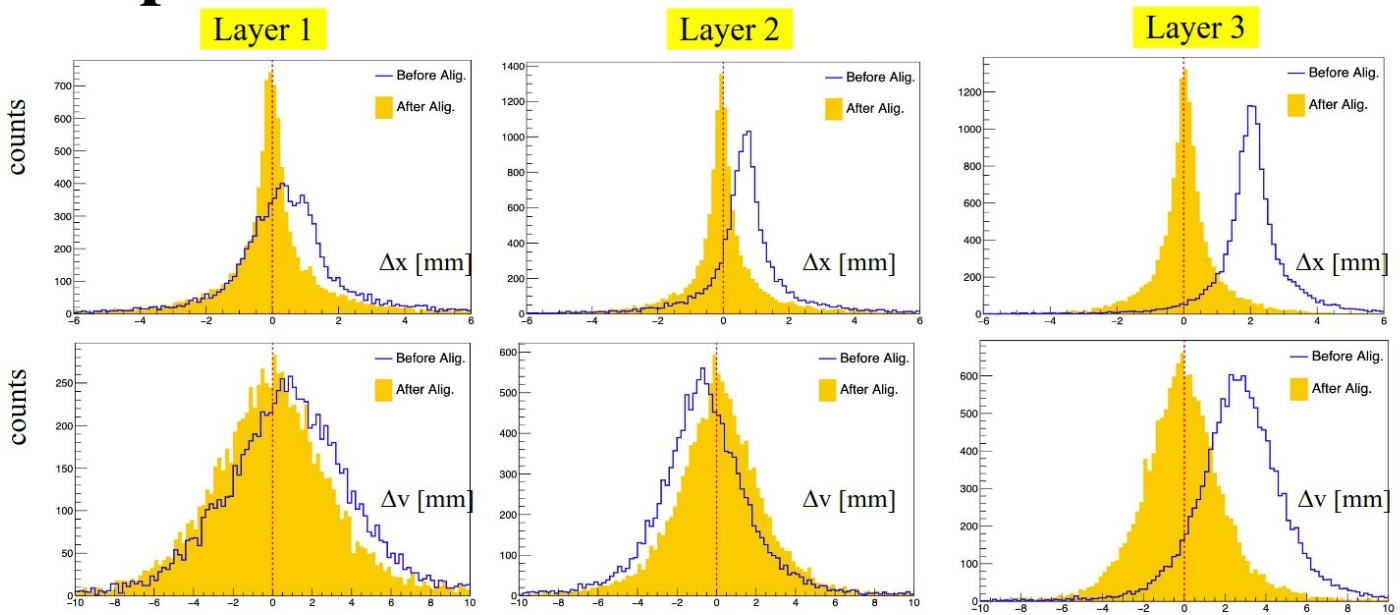
X Residuals vs. φ



X residual distribution improved significantly!

News from the last CM

Improvement of Residual Distributions



The **shift** of the residual distribution have been improved significantly!

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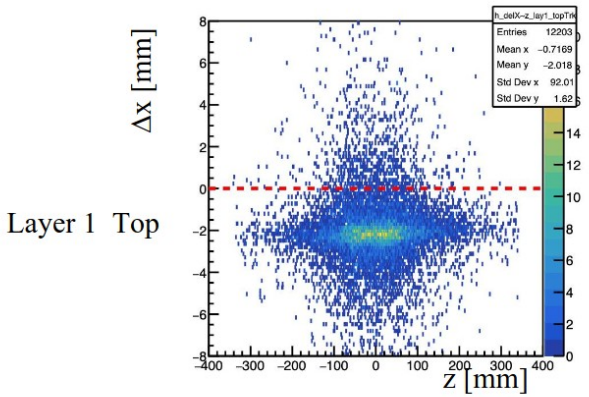
News from the last CM

Calibration of Lorentz Angle

1. Analyze cosmic-ray data with B=1T, applying alignment parameters obtained from cosmic-ray data with B=0
2. Estimate **α** from the shift of X residuals



Δx vs. z for the magnetic-field-on data
(using the alignment parameters from Step 1.)

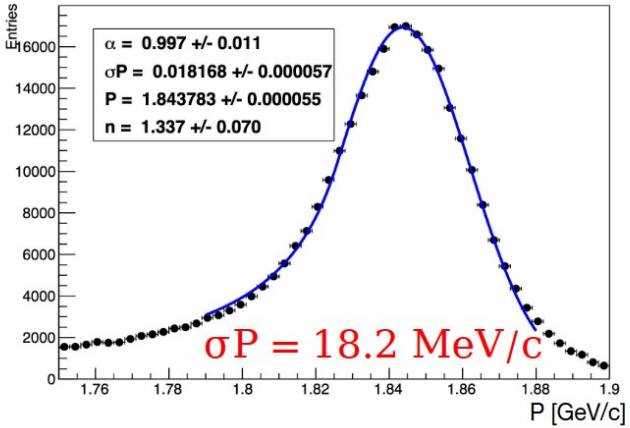
Layer	α (°)
1	14.67 ± 0.07
2	14.25 ± 0.01
3	13.65 ± 0.01

Summary from the CM

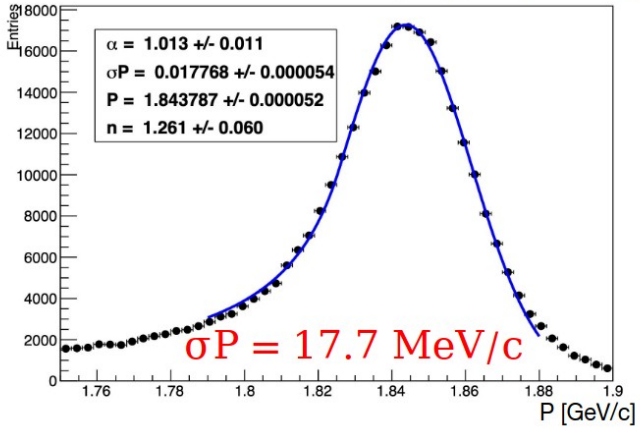
Momentum Resolution: with or without CGEM-IT

Yaxuan Li
Linghui Wu
Liangliang Wang

Only ODC



ODC + CGEM (aligned)



- Momentum resolution improved slightly
- To be improved after further optimization of reconstruction and calibration

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Summary from the CM

- Still lot of items to be done

- Two pressing questions for our community:
  - Where we can help?
  - Who can help?

Plans and needs

- We have to start a task force to work on the software
  - This includes Data quality
    - Create some shift from Italy?

- As discussed with Stefano, we have to start to be capable of running at least cosmic reconstruction
  - Find a list of good run (see above)
  - Use the code developed by Ben in the summer
  - Upgrade by using the new input from JIANG Di

Summary and outlook

- At the CM presented lots of new results
  - First extraction of momentum resolution
  - Alignment in a reasonable shape
  - uTPC preliminary results very encouraging

- Up to now we do have little control and even smaller contribution
  - We have at least to carefully check the data
  - Act:
    - Convince IHEP counterparts to share more
    - Organize effort
    - We submitted the proposal for a three months stay at IHEP for a master student

Comments, suggestions?

Thanks!